

Evolving Energy-IEF International Energy Congress (IEF-IEC2012)

## Review of wind energy utilization in South Asia

Iftekhhar Khan<sup>a,\*</sup>, Harun Chowdhury<sup>a</sup>, Roesfiansjah Rasjidin<sup>a</sup>, Firoz Alam<sup>a</sup>, Tazul Islam<sup>b</sup>,  
Sadrul Islam<sup>c</sup><sup>a</sup>*School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, Bundoora, Melbourne, VIC 3083, Australia*<sup>b</sup>*Department of Mechanical Engineering, Chittagong University of Engineering and Technology, Chittagong 4349, Bangladesh*<sup>c</sup>*Department of Mechanical and Chemical Engineering, Islamic university of Technology, Gazipur 1704, Bangladesh*Elsevier use only: Revised 30<sup>th</sup> July 2012; accepted 27<sup>th</sup> August 2012

---

**Abstract**

Due to huge population and economic growth, the demand for power and energy is increasing rapidly in most Asian countries especially in India, Bangladesh and Pakistan where the power generation is based mainly on fossil fuel. Power generation from renewable energy sources especially wind energy has not been well utilised in South Asia. In comparison, European countries and countries in North America have made significant progress in wind energy utilisation for power generation. Scant information on utilisation of renewable energy for power generation in Bangladesh, Pakistan and India is currently available in the public domain. Therefore, the primary objective of this study is to undertake a comparative analysis of wind energy utilisation for power generation in South Asian countries. The analysis includes current power generation by fuel types and the government initiatives and policies on wind energy utilisation. The study indicates that India is significantly ahead in wind energy utilisation compared to other two countries Bangladesh and Pakistan. The main obstacle for utilising wind energy is the lack of clear policy and government initiatives. However, all three countries have ambitious plans for wind energy utilisation in the future.

© 2012 The Authors. Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the International Energy Foundation

Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).*Keywords:* Wind energy; renewable energy; energy policy; Bangladesh; Pakistan; India

---

**1. Introduction**

Depletion of finite fossil fuel resources, concern for energy security and greenhouse gas emission compel governments and policymakers to develop new strategies to utilize renewable energy sources and clean energy for power generation. Wind energy has emerged as one of the most viable alternatives based on cost and resources availability. The appeal of wind energy evidenced by its present progress in the global energy market may be attributed to its minimum adverse impact on the environment, and its competitive use in multi-scale applications both in grid connected modes as well as standalone facilitation in remote areas. An estimate by the World Wind Energy Association shows that the worldwide wind capacity reached 215,000 MW by the end of June 2011. About 18,405 MW were added in the first six months of the year 2011. In 2011, the world's top five wind power generating nations were: China (62,733 MW), USA (46,919 MW), Germany (29,060 MW), Spain (21,674 MW) and India (16,084 MW), constituting together a total share of 74% of the global wind energy utilization. In 2011, China was the largest producer of power from wind energy, adding 8 GW in the first half of the same

---

\* Corresponding author. Tel.: +61 3 99256103; fax: +61 3 99256108.E-mail address: [iftekhhar.khan@rmit.edu.au](mailto:iftekhhar.khan@rmit.edu.au)

year. Despite the rapid progress in power generation from wind in recent time, most South Asian countries except India are at the primitive stages of harnessing the wind energy for power production.

At present, over 85% of the total power in Bangladesh, India and Pakistan is generated from fossil fuel. Most power plants in Bangladesh and Pakistan are based on natural gas. The increasing consumption of gas by power plants has been far outstripping any increase in supply and production. This leads to severe gas deficits in power plants, industrial and domestic uses; which by any measure, is unsustainable. The cost of power generation by wind is in par with the coal based power cost as shown in Table 1.

Table 1. Estimated levelized cost of new generation by the year 2016 (adapter from [1])

| Type of Power Source         | Price in kilowatt-hour generation <sup>1</sup> in different currency |                  |                |             |
|------------------------------|--|------------------|----------------|-------------|
|                              | U.S Cents  | Bangladesh (BDT) | Pakistan (PKR) | India (INR) |
| Conventional Coal            | 9.48   | 7.64             | 8.82           | 5.26        |
| Advanced Coal                | 10.94  | 8.82             | 10.17          | 6.07        |
| Advanced Coal with CCS       | 13.62  | 10.98            | 12.67          | 7.56        |
| Natural Gas-fired            |  |                  |                |             |
| Combined Cycle (Average)     | 7.28   | 5.87             | 6.77           | 4.04        |
| Combustion Turbine (Average) | 11.4   | 9.19             | 10.6           | 6.327       |
| Advanced Nuclear             | 11.39  | 9.18             | 10.59          | 6.32        |
| Wind                         | 9.7  | 7.82             | 9.02           | 5.38        |
| Wind Offshore                | 24.3   | 19.59            | 22.6           | 13.49       |
| Solar PV                     | 21.07  | 16.98            | 19.6           | 11.69       |
| Solar Thermal                | 31.18  | 25.13            | 29             | 17.3        |
| Geothermal                   | 10.17  | 8.2              | 9.46           | 5.64        |
| Biomass                      | 11.25  | 9.07             | 10.46          | 6.24        |
| Hydro                        | 8.64   | 6.96             | 8.04           | 4.8         |

The table shows an estimated levelised cost of new generation by the year 2016 in different currency of US Cents, Bangladeshi Taka (BDT), Pakistani Rupee (PKR) and Indian Rupee (INR). The table clearly depicts the effective and competitive advantages of establishing wind energy based power plants compared to other energy based power generation. With the present pace and competitive utilisation of wind energy for power generation worldwide, it is necessary to explore the present and future wind energy utilisation in South Asian countries especially in Bangladesh, Pakistan and India.

Therefore, the main objective of this paper is to review the present scenarios and government policies for power generation from the wind in Bangladesh, India and Pakistan, and undertake a comparative analysis of current wind energy utilization for power generation among these three countries.

## 2. Status of wind energy utilization in Bangladesh

In terms of territory, Bangladesh is one of the smallest countries. However, based on population, Bangladesh is the 9<sup>th</sup> largest countries in the world. It is situated in between 20°34'-26°03' North Latitudes and 88°04'-92°04' Longitudes. It has approximately 750 km long coastal belt. Besides it has more than 200 km long hilly coast line and many small islands in the Bay of Bengal. In summer a strong south westerly trade wind and sea-breeze blows, and in winter there is a gentle north-easterly trade wind and land breeze over Bangladesh. To generate wind energy, a good speed of wind across Bangladesh has been reported in [2].

Initiative for power generation from wind energy was first undertaken in 2005, when Bangladesh Power Development Board (PDB) under the Ministry of Power, Energy and Mineral Resources of the government of Bangladesh installed four turbines with a total power generation capacity of 900 KW at Muhuri Dam in Feni District of greater Noakhali region. Later 50 wind turbines were established in Kutubdia Island, with a total generation capacity of 1 MW, as shown in Fig 1. There after several initiatives for the installation of wind turbines to produce power were undertaken. However, these initiatives were not materialized. In the Master Plan for the year of 2011 to 2016 for power generation by the Ministry of Power, Energy and Mineral Resources, the Government of Bangladesh, a total of 100 MW power from the wind was planned by the year 2013 at Anwara, Chittagong. The proposed plan would be as Independent Power Production Model.



Fig. 1. Wind turbines at Kutubdia, Chittagong, Bangladesh

As mentioned in [3], the potential of wind energy in Bangladesh is not yet fully explored due to the lack of wind data and reliable wind history data. Bangladesh Centre for Advanced Studies (BCAS) in collaboration with Local Government and Engineering Department (LGED) and an international organization namely Energy Technology and Services Unit (ETSU) from UK with the funding from DFID have attempted to monitor wind conditions at seven coastal sites for a period of one year in 1996-97. They measured wind parameters at a height of 25m. However, no concrete findings on wind conditions from these seven sites were reported to public domain.

Some non government organizations such as Bangladesh Rural Advancement Committee (BRAC) and Grameen Shakti also attempted to identify the wind energy potentials in Bangladesh. In the initial stage BRAC had installed 11 small wind turbines in various coastal sites and Grameen Shakti installed two wind generators of 300 W and 1 KW each at a shrimp farm located at Chakaria, Chittagong. Later Grameen Shakti installed 4 more small wind turbines in Barguna District, a southern coastal region of Bangladesh. The primary objective of this initiative was to identify the possible harnessing of wind energy for small businesses and communities in remote rural areas. These initiatives were reinforced by combined utilisation and integration of solar PV and small diesel fired generators with the power generated from the wind. One of the main objectives of various NGO's initiatives was not to make a significant power generation from the wind to the national power grid but to assist small scale business, agriculture and supplying energy to remote areas where no grid connections are available. Several potential applications were identified. These applications are water pumping, fish drying, shrimp production, fish/poultry firming, salt/ice production, fish-mill industries, hatcheries, domestic applications and agricultural irrigation. In recent years, LGED has set up a number of 8.23 meter high wind pumps in Tangail, Kushtia, Cox's Bazar and several other locations. The maximum capacity of wind pumps located in those locations is 0.5 horse power (385 W) at wind speed of 4 m/s. The output of the pump was found to be 25 litre / minute at wind speed of 3.2 m/s. Besides, BCAS installed a wind pump which was designed by Intermediate Technology Group of UK and manufactured in Pakistan. This wind pump was installed in an agricultural field at Patenga in Chittagong. The average water output between November and January was reported to be about 8000 litres/day.

## 2. Wind energy in India

India is significantly ahead of all other South Asian countries in the utilization of wind energy for power generation. The Ministry of New and Renewable Energy (MNRE) of the Government of India, in coordination with the state governments implemented the wind resource assessment program. At 221 wind monitoring stations, it found mean annual wind power density greater than  $200\text{W/m}^2$  at 50m height. The demonstration projects of power generation from wind energy were started in 1985 in India. In the initial demonstration projects with 69.6 MW power generation capacity wind turbines were established at 33 locations in nine states of India. Five wind farms were established in 1986 with a total power generation capacity of 3.3 MW. First commercial wind power generation was commissioned in 1990 at Kattadilalai, Muppandal, Tamilnadu. Till March 1992, the wind power installed capacity was 41.18MW. Initially, wind farms in India were installed in the coastal areas of Tamilnadu, Gujarat, Maharastra and Orissa. Now wind turbines have been installed in over nine states of India. Since 1996, the wind energy in India has started a rapid growth. In 2004, 2 MW power generation capacity wind turbine was built in India which was considered to be the biggest and tallest wind turbine in Asia. The Indian Renewable Energy Development Agency (IREDA) under the Ministry of New and Renewable Energy (MNRE) played a key role in wind energy harnessing in India. Appropriate and long term research and policy adaptation has attracted international

financial organizations, local and international investors to invest heavily in wind energy sector in India.

In last two decades Indian wind energy generation has achieved a tremendous growth from 41.3 MW in 1992 to 13,065 MW at the end of 2010. Among the states, Tamil Nadu stands on top in energy generation from the wind. Other states like Gujarat, Maharashtra and Rajasthan also achieved a significant growth in last five years.

The Centre for Wind Energy Technology (C-WET) published the Indian Wind Atlas in 2010, which shows large areas with annual average wind power densities of more than 200 Watts/m<sup>2</sup> at 50 meter above ground level (MAGL) [3]. It has projected that the India has a potential of wind power generation of 49,130 MW at 2% land availability. Fig 2 shows wind turbine installations in Dhule, Maharashtra.



Fig. 2. Chhadvel wind turbines in Dhule, Maharashtra, India

### 3. Wind energy in Pakistan

In 2001, Pakistan Council for Renewable Energy Technologies (PCRET) was established by merging with the National Institute of Silicon Technology (NIST) and Pakistan Council for Appropriate Technologies (PCAT) [4]. The main responsibility of PCRET is to coordinate research and development activities on renewable energy technologies in the country, particularly in the areas of microhydel power plants, biogas, fuel-saving technologies, solar thermal appliances, photovoltaic and wind energy. Alternative Energy Development Board (AEDB) was established on May 2003 by the Government of Pakistan to act as the central national body on establishment of renewable energy. The main objective of the Board was to facilitate, promote and encourage development of renewable energy in Pakistan with a view to introduce alternative/renewable energy at an accelerated rate to achieve 10% share of renewable energy in the energy mix of the country by 2015 [4].

Under the USAID assistance program, the National Renewable Energy Laboratories (NREL), USA has carried out a study on the wind resources of Pakistan and developed a map showing the wind speed potential locations at 50 m altitude. This wind resource map has opened a window of opportunity to harness the wind energy resources. It identified the potential regions for wind energy in Pakistan with 346,000 MW power generations potential. Several regions were identified for the potential wind farms establishment. These regions are: the hilltops region of Karachi-Hyderabad, ridges in the northern Indus Valley, wind corridor in western Pakistan, hills and ridges in south-western Pakistan. The data shows that the coastal belt of Pakistan has a wind corridor of 60 km wide and 180 km long. This corridor is named as Gharo-Keti Bandar wind corridor. This corridor has an exploitable wind power potential of up to 50,000 MW. About 30% ~ 32% capacity factor is estimated in Gharo-Keti Bandar area. These potential areas have become the focal point for the development of wind energy for future energy planning of Pakistan. Despite some noticeable progresses in wind resources mapping and wind farm site locations, Pakistan has been facing some problems in developing its wind energy sector. These problems are mainly associated with the lack of government policies and budgetary constraints, political stability, failure to attract foreign and local investments in wind energy, lack of historical proven and bankable wind data, flood mitigation for potential sites for wind farms, lack of technological knowhow, skilled manpower, inadequate infrastructures development for the access to potential wind farm sites, lack of harmonisation province and federal policies on renewable energy, and inadequate overall energy policy.



Fig. 3. Zorlu Wind Farm at Jhampir, Sindh, Pakistan

Recently, feasibility studies for 50 MW wind power projects have been submitted by thirteen (13) IPPs (Independent Power Producers). The National Electric Power Regulatory Authority (NEPRA) so far issued Generation Licenses to following seven IPPs:

- a) Green Power Pvt. Ltd.
- b) New Park Energy Ltd.
- c) Tenaga Generasi Ltd.
- d) Dawood Power Ltd.
- e) Zorlu Enerji Pakistan Ltd.
- f) Arabian Sea Wind Energy Pvt. Ltd.
- g) Fauji Fertilizer Company Energy Ltd.

NEPRA also announced tariff determinations for five IPPs. In October, 2008, Pakistan started its first wind power plant named as Jhampir Wind Power Plant. The plant is located 70 km from Karachi at a location called Jhampir (see Fig 3). It consists of five wind turbines and constructed by 'Zorlu Enerji Pakistan', a local subsidiary of a Turkish company. Each of the five wind turbines has a generation capacity of 1.2 MW. Total three phase has been determined for the project, on which 6 MW capacity was installed at the initial phase. It was planned to generate 50 MW in the second phase and 300 MW in the third phase at the same location. At present the Turkish wind farm is selling the produced electricity to Pakistan at a rate of 12.11 US cents per Kilowatt hour of electricity. The project is ongoing and planned to be completed by the end of 2012. Total cost of the project was estimated to be around 110 million US dollar.

As reported in [5], the Pakistan's wind energy planning in 2004 was categorised in three consecutive term planning. First one was short term planning for 2005-2010 to install 700 MW generation wind turbines. The short term goal failed miserably as Pakistan was able to produce only 6 MW from wind energy by the end of 2011. The medium term goal is to establish 3,850 MW power generation capacities from the wind by the year 2020, and the long term goal is to establish 9,700 MW wind power generation beyond 2020. With current pace of wind energy harnessing in Pakistan, there are significant uncertainties due to economical and political turmoil, in achieving the future success of medium and long term wind energy goal.

#### 4. Comparison of Wind Energy Utilisation in Bangladesh, Pakistan and India

As shown in Table 2, both Bangladesh and Pakistan are heavily dependent on natural gas as energy source to produce power. The power generation dependency of Bangladesh, Pakistan and India is on natural gas around 80%, 50% and 10% respectively. On the other hand, coal constitutes 55% energy sources for power generation in India, 8% in Pakistan and 4% in Bangladesh. Additionally, India leads significantly in hydro power generation compared to the other two countries. India and Pakistan possess excellent hydro resources thanks to Himalayan mountain ranges. Currently, India produces around 21% power from hydro resources compared to 11% of Pakistan and around 3% of Bangladesh. In terms of wind energy utilisation, Bangladesh produces only 0.028% power from the wind compared to India's 7.2% and Pakistan's 0.33% of their individual total energy. Bangladesh is dangerously dependent on its power generation from the natural gas (as mentioned

over 80%). Its power generation based on coal and wind is negligible. It urgently needs to reduce its dependency on power generation from the natural gas and increase power generation from clean coal and renewable energy especially from the wind resources. If it continues its dependency on natural gas for power generation, it will face acute shortage in natural gas which will not only reduce its power generation capacity but also reduce capacity of fertilizer production, chemical and other industrial productions and household uses. This will in turn destabilise the country's food production, industrial and economical growth.

Table 2: Comparison of power generation by different energy source

| Energy source          | Percentage of cumulative power generation. |       |          |
|------------------------|--|-------|----------|
|                        | Bangladesh                                 | India | Pakistan |
| Coal                   | 3.64                                       | 54.80 | 7.60     |
| Gas                    | 79.86                                      | 9.75  | 48.90    |
| Oil                    | 13.14                                      | 0.66  | 32.10    |
| Hydro                  | 3.35                                       | 21.04 | 10.60    |
| Nuclear                | 0  | 2.63  | 0.70     |
| Wind                   | 0.028                                      | 7.20  | 0.03     |
| Other Renewable Source | 0.3  | 3.92  | 0.95     |

In Table 3, a comparison of different aspects related to wind energy in Bangladesh, India and Pakistan is given. The table provides a comprehensive picture of growth of power generation from wind in these three countries. Bangladesh started its wind energy generation in 2005 and to-date its wind energy generation is merely 1.9 MW which is just 0.028% of total power generation. Having relatively better GDP than Pakistan, Bangladesh is in good position to focus on renewable energy utilization especially from wind. In order to utilize wind energy for power generation, the first step needed is for Bangladesh to develop a comprehensive wind resources mapping for the whole country especially along its coastal belts. In comparison, India and Pakistan have made significant progress in wind resources mapping. It may be noted that the wind mapping is paramount to harness the wind resources. The wind map provides a comprehensive data on wind's average hourly, daily, monthly & yearly speed, turbulence intensity, and direction. Additionally, it also provides data on rain fall, solar radiation, relative humidity and air temperature. Khan et al. (2004) generated a wind map with several micro scale features and found that small-scale wind turbines could be installed in locations such as St. Martins Island, Cox's Bazar, Patenga, Bhola, Barguna, Dinajpur, Thakurgaon and Panchagar in Bangladesh [6]. Bangladesh puts a significant emphasis on solar energy utilisation than wind energy recently. At present, the cost of producing power from wind approximately BDT 12 per kilowatt hour (kWh) compared to BDT 25-30 for solar plants in Bangladesh. The Power Development Board of Bangladesh has recently acknowledged that the main hindrance to wind power development in Bangladesh is the lack of reliable wind data along its 750 km coastline. A very limited currently available data is extremely unreliable, confusing, outdated, and moreover, it does not cover the entire coastline. In 2012, Bangladesh signed a contract with an Indian wind turbine manufacturing company to install wind turbines with a capacity of 15 MW. Additionally, Power Cell, the Government of Bangladesh has planned to generate 1,000 MW power from the wind by 2020 [7].

India showed a tremendous progress in wind energy generation compared to Bangladesh and Pakistan. Fig 4 shows India's rapid growth in power generation from the wind till 2011. Since 2011, India's generation capacity exceeds 13,065 MW from wind energy, constituting over 7.20% of the total energy generation. Several Indian home grown wind turbine manufacturing companies especially Suzlon make it much easier to expand wind harnessing technology and to produce skilled manpower. India's wind energy initiatives started a decade ago compared to Pakistan and Bangladesh.

As mentioned earlier, the wind energy development in Pakistan is also very slow. Since its first wind turbine installation in 2008, no further follow up and initiatives were taken to harness the wind energy despite its vast potential. However, the Pakistani authority is expecting the planned Jhimpir wind farm will generate 50 MW at the end of 2012. If the government wish to utilise its vast wind resources and properly implement its 3 phase plans, Pakistan is still in a position to generate 9,700 MW from the wind by the year of 2030.



Table 3: Comparison of wind energy generation progress

| Country                                  | Bangladesh           | India      | Pakistan   |
|--|----------------------|------------|------------|
| GDP Growth (%)                           | 6                    | 8.2        | 3.8        |
| Starting Year                            | 2005                 | 1997       | 2008       |
| Wind Mapping                             | Not Undertaken       | Undertaken | Undertaken |
| Total Power Generation Capacity (MW)     | 6,688                | 1,81,558   | 18,167     |
| Present Wind Power (MW)                  | 1.9                  | 13,065     | 6          |
| Percentage of Total Power                | 0.03                 | 7.20       | 0.03       |
| Projected Wind Power by 2030 (MW)        | 5,000*               | 51,249     | 9,700      |
| Target Percentage of Total Power by 2030 | No Percentage Target | 10         | 5          |

\*Bangladesh government plans to achieve this target by the year 2020.

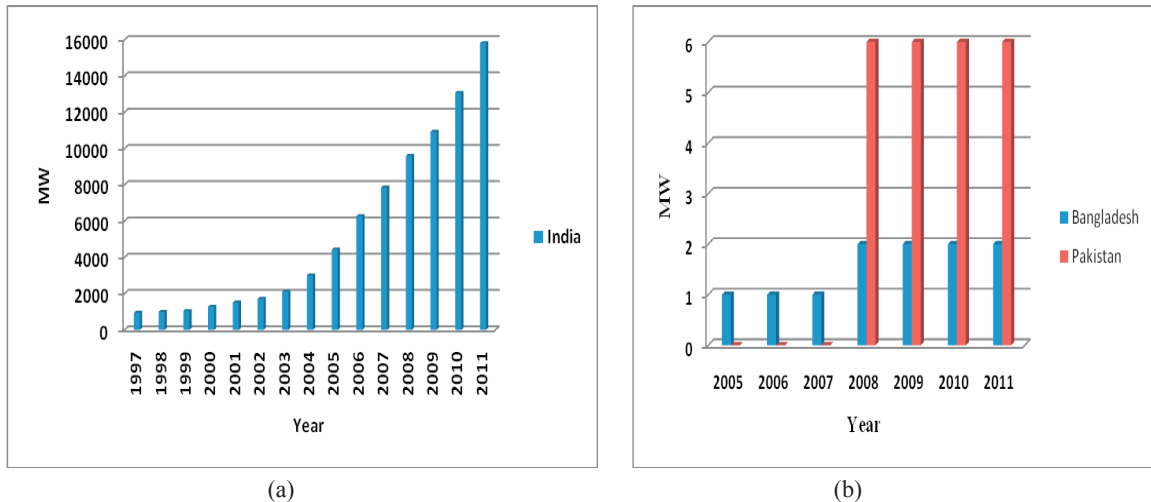


Fig. 4. (a) Wind power generation in India, (b) wind power generation in Bangladesh and Pakistan

## 5. Concluding Remarks

Wind energy has been proven to be the true alternative renewable energy source compared to fossil fuel based power generation worldwide. The power generation cost from the wind is now close to the cost of power generated from fossil fuel. Wind energy is vital for ensuring a clean energy for the future. Due to huge green house gas emissions from thermal power plants and uprising price of fossil fuels, the power generation from the wind at a competitive cost will be the appropriate alternative to mitigate global environmental and fossil fuel depletion concerns. The utilization of wind energy for power generation has a significant importance for the South Asian countries especially Bangladesh, India and Pakistan due to their high population densities, huge power demands and rapidly expanding economies. The study indicates that both Bangladesh and Pakistan are notably lagging behind to reach a progressive goal in utilization of wind resources. In contrast, India achieved a tremendous growth in harnessing wind energy. It has developed technological knowhow as well as skilled human resources in wind energy sector. For the proper utilization of wind energy, Bangladesh needs a comprehensive nationwide wind mapping to determine its wind energy recourses and locate potential sites for large scale wind farms. Both Bangladesh and Pakistan can benefit immensely by cooperating and sharing Indian technological knowhow and experience in harvesting of wind resources.

## References

- [1] Energy Information Administration, Annual Energy Outlook 2011, DOE/EIA-0383(2010), December 2010
- [2] Rahman, F.M., 1996. Prospects of Wind Energy in Bangladesh. Renewable Energy 9, p. 8006-8009.
- [3] Islam, M.T., 2001. Wind Energy Resources Mapping (WERM) Project for Bangladesh. Mechanical Engineering Research Bulletin 1, p. 23-28.

- [4] Mirza, U.K., Ahmad, N., Majeed, T., Harijan, K., 2007. Wind Energy Development in Pakistan. *Renewable and Sustainable Energy Reviews*, 11, p. 2179–2190.
- [5] Khalil, M.S., Khan, N.A., Mirza, I., Jafri, S.A., 2006. “National wind energy development program”, 3rd BSME – ASME International Conference on Thermal Engineering, Dhaka, Bangladesh.
- [6] Khan, M.J., Iqbal, M.T., Mahboob, S., 2004. A Wind Map of Bangladesh, *Renewable Energy*, 29, p. 643-660.
- [7] Shah, J., 2012. Role of ADB in Supporting Renewable Energy in Asia and Pacific: Quantum Leap in Wind Initiative, Retrieved from [windenergy.org.nz/documents/conf11/jshah.pdf](http://windenergy.org.nz/documents/conf11/jshah.pdf) on 10 June 2012